Forest Insect & Disease Management

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BIOLOGICAL EVALUATION

Spruce Budworm on the Nicolet and

Chequamegon National Forests, Wisconsin, 1980

by

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INTRODUCTION

The current spruce budworm (Choristoneura fumiferana (Clemens)) outbreak in northern Wisconsin is in its fifth year. The outbreak started on the Nicolet National Forest in 1975 and has been at outbreak levels on the Chequamegon National Forest for the past three years. This outbreak has resulted in the loss of 177,505 cords (591 m^3) of timber. Of this loss, 76 percent was on the Nicolet (134,996 (449)) and 24 percent on the Chequamegon (42,509 (142)). An additional 206,447 cords (688 m^3) are dying; this is a total of 383,952 cords (1279 m^3) of wood that is now or will be dead in 1981 because of spruce budworm defoliation. Most of the loss has been balsam fir pulpwood stock. About half of the threatened or dying fir is being salvaged but the remainder is inaccessible for various reasons and must be left to be defoliated by spruce budworm.

The Timber Staff Officers of the two National Forests requested a biological evaluation of the spruce budworm situation in selected high value stands. These stands consist of white spruce (Picea glauca (Moench) Voss), eastern hemlock (Tsuga canadensis (L.) Carr.), and some mixture of balsam fir (Abies balsamea (L.) Mill.). The biological evaluation was done in September and October, 1980.

OBJECTIVE

The objective of this evaluation was to determine the current condition and potential for continued defoliation in selected white spruce and hemlock stands in 1981.

METHOD

Criteria for selection of stands for evaluation were made by the respective Forest on the basis of: 1) stands of high value, special interest or recreational use; 2) susceptible host type; 3) accessibility for survey personnel and; 4) geographic location within the Ranger District.

A compartment within a Ranger District may be divided to include more than one stand of a given forest type. Where there was more than one selected stand of the host type within a compartment the stands were grouped into a single sampling area. In compartments with a single selected stand, this stand was considered a sampling area by itself.

Both intensive and extensive surveys were done. The same two survey procedures were used on each Forest to cover as many of the selected stands as possible within time, mileage, and personnel restrictions.

The intensive survey involved branch sample collections within each sampling area for budworm egg mass population levels (1980), defoliation levels, and tree condition.

Clusters of three dominant or codominant live host trees were selected for the branch samples within each sampling area. The number of clusters in each sampling area varied as:

3 clusters - 1 to 25 acres (0.4 to 10 ha) in sampling area.
5 clusters - 26 to 100 acres (10.5 to 40 ha) in sampling area.
8 clusters - 101 or more acres (40.9 ha) in sampling area.

Clusters were distributed randomly throughout the sampling area.

Three sample branch tips, 15-inches (38-cm) long, were cut by pole pruner from the midcrown of each cluster tree for egg mass and defoliation determination. These samples were brought back to the laboratory where egg masses were counted on each branch tip and classed as hatched, parasitized, or nonviable. Old egg masses were not recorded. The average number of masses per branch for each sampling area was computed.

The sample branch tips of spruce were used to estimate 1978, 1979, and 1980 defoliation. Estimates of 1978 and 1979 defoliation on a spruce branch were combined and averaged to judge the extent of damage in those years. Since hemlock does not retain needles for 3 years, past hemlock defoliation estimates were available for 1979 only. The Fettes classification system was used to make 1980 defoliation estimates (Fig. 1). This system accounts for loss of buds as well as needles. Average percent defoliation (1978-1979) and a Fettes class were calculated for each intensively sampled area.

The extensive survey consisted of a visual examination of the selected stand to estimate the tree vigor, 1980 defoliation level, and to find empty budworm pupal cases.

The relative vigor or condition was estimated for each sample tree. This highly subjective estimate of good, fair, poor, or very poor condition was based on past defoliation, relative new shoot length, number of dead twigs, and chances of survival if budworm attack ended. A tree in poor condition would probably survive if not heavily defoliated in 1981, but a tree in very poor condition would not survive even if there were no budworm feeding in 1981.

RESULTS

Nicolet National Forest

Thirteen white spruce and 19 hemlock stands need no treatment. Five are in such poor condition that they can not be saved, even if treated with insecticides. Twenty-seven stands are in good condition and need no special treatment now to prevent damage by the budworm (Appendix A). Past defoliation in these latter stands ranged from 2 to 43 percent, 1980 defoliation was 12 percent (Fettes Class 2) and tree condition was good. The egg mass sample in 19 of the stands indicates a low budworm population of 0.08 masses per 15-inch (38-cm) branch (Table 1).

In 62 sample stands, (Appendix B) past defoliation (the sum of 1978 and 1979 defoliation except on hemlock) was 81 percent (n=41 stands, 207 trees). On hemlock, 1979 defoliation was 47 percent (n=21 stands, 63 trees). Present defoliation of 270 sample trees was 55 percent or 6.0 under the Fettes classification. The average condition of the sample trees was 1.23 where 1 is fair and 2 is poor. There were 0.61 hatched egg masses and 0.10 parasitized egg masses per 15-inch (38-cm) branch tip (n=810 branches). The 14 percent parasitism is the usual low rate in spruce budworm outbreaks and indicates that parasites of spruce budworm eggs did not have much impact on the budworm population. The eggs laid in 1980 have hatched and the budworms are now hibernating on the trees as second instar larvae. They will emerge in 1981 to defoliate the trees. Each egg mass contains about 25 eggs. The 0.61 egg masses per branch tip means that there are about 80 chances in 100 that the trees will be moderately to heavily defoliated in 1981 (Table 1). Although Table 1 was developed for balsam fir in Minnesota, it gives our best estimate of conditions on hemlock and white spruce in Wisconsin. The table is taken from an unpublished report by J. L. Bean and H. O. Batzer, North Central Forest Experiment Station, 1961.

Chequamegon National Forest

On the Chequamegon National Forest, 21 stands were intensively sampled and 59 stands were extensively sampled. These 80 stands constituted all of the evaluation requested by the foresters.

Eleven white spruce, 12 hemlock, and one black spruce stand were found to have low egg mass populations and/or a low level of defoliation. In these white spruce stands, the hatched egg mass population averaged 0.04 per sample branch tip (n=234) and 0.01 parasitized masses. The 27 percent parasitism is higher than that found in the Nicolet sampling, but still insufficient to control an upsurging budworm population. Thirty-three acres (15 ha) were classed as heavy defoliation (60-90 percent) and 239 acres (97 ha) were light to moderate (0-60 percent) for 1980. These stands do not need treatment in 1981 (Appendix A).

Fifty-six stands of white spruce were found to be in need of treatment to prevent severe growth loss. Hatched egg masses averaged 0.68 masses per branch tip (n=576). Parasitized egg masses averaged 0.33 per branch. Twenty-six percent of all collected egg masses were parasitized. Defoliation (1980) at heavy and severe levels (60-100 percent) was found on 1,647 acres (667 ha) with 547 acres (221 ha) classed as light to moderate. Two stands of balsam fir extensively surveyed, (146 ac (59 ha)) were also heavily defoliated (Appendix B).

DISCUSSION

The spruce budworm outbreak, which started on the Nicolet National Forest near Three Lakes, Wisconsin, has spread northward and expanded as it intensified. Small, localized outbreaks are also occurring to the south and east of Three Lakes. Several stands have thus far escaped noticeable defoliation in the Lakewood and Laona Districts. Tree mortality is most common in old growth hemlock stands on the Eagle River District where drought stressed the trees and budworm damage has hastened mortality.

On the Chequamegon, the origin of the current outbreak is not clearly defined. Historically, outbreaks have tended to begin on the Hayward and Glidden Ranger Districts. The limited number of white spruce stands selected for this evaluation indicates a spotty distribution of outbreak populations, causing high levels of defoliation on three of the four Districts.

Outbreaks of spruce budworm on hemlock are uncommon so there is no mention of damage levels or budworm behavior in the literature. However, it is known that hemlock does not tolerate defoliation by other insects such as the gypsy moth (*Lymantria dispar* (L.)) or the hemlock looper (*Lambdina fiscellaria fiscellaria* (Guénee)). If defoliation does not kill the tree directly, ((*Armillariella mellea* Vahl ex. Fr.) Karst) root rot readily invades damaged hemlock. According to Secrest[1/] stressed trees are vulnerable to the hemlock borer (*Melanophila fulvoguttata* (Harris)) and other mortality factors associated with root rot. Healthy trees are not successfully attacked by the hemlock borer.

[1/] H. C. Secrest. 1943. Unpublished report on the hemlock borer, its biology, and a discussion of the factors concerned in the development of an infestation on file at State and Private Forestry, St. Paul Field Office, 1992 Folwell Ave., St. Paul, MN 55108.

White spruce is a common host of the spruce budworm but is not as vulnerable as balsam fir. Even though white spruce may appear to recover after heavy budworm attack, the tree remains susceptible to bark beetle attack for about 5 years during its recovery period (Thomas 1958). Because white spruce retains its needles for 5 to 7 years, it can tolerate several years of heavy defoliation and remain alive, unless under other stresses. Sample trees in this evaluation have suffered 2 to 3 years of moderate to heavy defoliation and are now in fair to poor condition.

CONCLUSION

The spruce budworm outbreak on the Nicolet and Chequamegon National Forests will continue in 1981. Tree condition is generally fair, but many stands now have dead hemlock trees and spruce or hemlock in poor condition. On the Nicolet National Forest, 3938 acres (1594 ha) of white spruce in 118 stands and 1204 acres (487 ha) of hemlock in 63 stands (total 5142 acres (2082 ha)) need treatment. On the Chequamegon, 2194 acres (888 ha) in 51 white spruce stands show defoliation levels requiring treatment to prevent further growth reduction and potential mortality.

RECOMMENDATION

Forest Pest Management recommends that silvicultural techniques such as thinnings, delaying release cuttings, presalvage of heavily damaged fir stands, and encouragement of mixed hardwood-spruce or hemlock-pine stands be integrated with release of Bacillus thuringiensis (B.t.) in selected high value stands of white spruce and hemlock. The B.t. should be aerially applied at the rate of 8 Billion International Units (BIU) per acre (20 BIU/ha) in a water suspension at the rate of 1 gallon per acre (9.4 L/ha). Application should be made in the spring, about May 30 when the budworm is at the peak of the third instar.

B.t. is a bacterium which affects many caterpillar species. The Environmental Protection Agency registered it for use against spruce budworm. Its residual effective period is about 3 days. B.t. must be ingested by the budworm to be effective. Once inside the host, B.t. spores produce crystals and toxins which kill the caterpillar. It is not believed to pass between generations of budworm, move between budworms, or hold over in the environment.

The application of the recommended integrated control program will not end the budworm outbreak or prevent future outbreaks. However, such a program will reduce the impact of the budworm on treated stands by reducing defoliation and preventing widespread premature tree mortality. Budworms from nearby untreated stands and survivors of B.t. release will again build to damaging population levels in the stands treated with B.t. Therefore, if the outbreak on the Forests persists because of favorable weather, the treated stands will need retreatment to protect their values. Since neither future budworm population flucuations or weather are predictable, another biological evaluation will be needed in 1981 to determine the need for further treatment programs.

There are no records of success or failure of B.t. applied to white spruce for control of spruce budworm; and it has never been applied to hemlock. The bacteria have been used successfully against several farm crop pests, gypsy moth, and spruce budworm on balsam fir. Populations were reduced about 60 to 90 percent and foliage saved was about 60 percent in the balsam fir treatments which is sufficient to keep trees alive.

Forest Pest Management entomologists will provide technical assistance in conducting and evaluating a B.t. project on the Nicolet and Chequamegon National Forests in 1981.

LITERATURE CITED

Thomas, J. B.
1958. Mortality of white spruce in the Lake Nipigon Region of Ontario. For. Chron. 34(4) 393-404.

FIGURE 1.

CURRENT YEAR DEFOLIATION

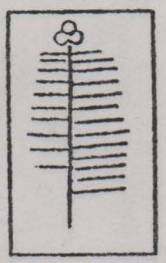
Spruce Budworm Biological Evaluation

Fettes Classification
and
Percent Defoliation

0

0

1



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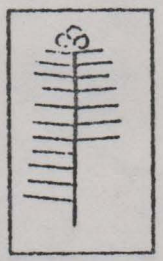

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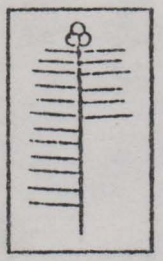

20-30

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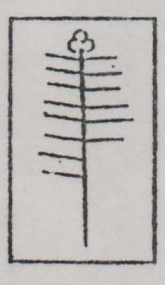

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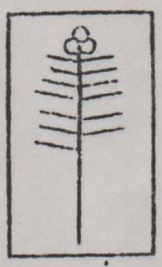

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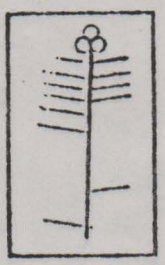

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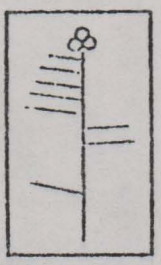

60-70

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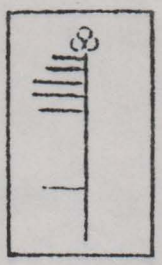

70-80

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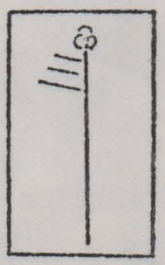

80-90

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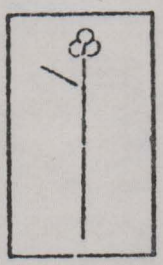

90-100

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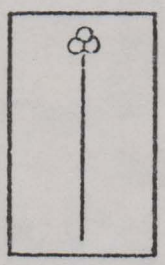
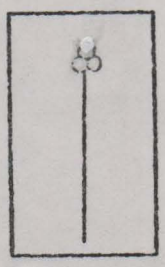


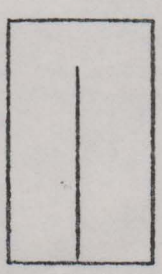
100

11+



100
Live bud.
Old bud
dead.

12



100+
Old bud dead.
No new bud.

Table 1.--Probability of different degrees of defoliation on balsam fir at any locality in northeastern Minnesota for the following year, based on the average number of egg masses per 15-inch twig per collecting point.

Average number of egg masses per 15-inch twig	Number of chances in 100 for the following degree of defoliation[1/]			
	None	Light	Moderate	Heavy
0-0.2	43	45	9	3
0.3-0.5	5	58	21	16
0.6-1.0	2	14	42	42
1.1-5.0		5	23	72
5.1-10.0			6	94
10.0 +				100

[1/] Defoliation classification: light, 5 to 25 percent defoliated; moderate, 30 to 50 percent defoliated; heavy 55 percent or more defoliated.

APPENDIX A

Stands of timber that were evaluated for spruce budworm damage and found to need no control in 1981.

Nicolet National Forest

White Spruce

District	Compartment	Stand(s)
Eagle River	34*	14
Florence	138*	32
Lakewood	35	22
	42	5, 27
Laona	35	11
	91	12
	145	4, 7, 24
	239**	5, 16, 19

Hemlock

District	Compartment	Stand(s)
Eagle River	10	9
	13	1
	35	5
	37	21, 31, 37
Florence	174	25
	177	13, 15, 16, 17
Lakewood	96	7, 13
Laona	28	15, 22
	105	8
	145	11, 12
	231	22

APPENDIX A (CONT.)

Chequamegon National Forest

White Spruce

District	Compartment	Stand(s)
Park Falls	73	8
	86	15
	104	11
	105	11, 30
	106	14
	110	14
	137	12, 22
	141	12, 16

Hemlock

District	Compartment	Stand(s)
Park Falls	118	6
	130	14, 18, 41
	131	2, 5, 10, 17
Medford	149	5

Black Spruce

District	Compartment	Stand(s)
Park Falls	131	40

*Very poor tree condition
**Severe frost damage

APPENDIX B

Stands of timber that were evaluated for spruce budworm damage and found in need of treatment to reduce further losses of forest values.

Nicolet National Forest

White Spruce

District	Compartment	Stand(s)	Acres
Eagle River	9	39	9
	26	13	26
	51	7	72
	57	5	89
	62	2, 4, 12, 23	210
	68	11, 16	106
	126	11, 19	70
	135	16	58
	148	14, 16, 17	14
	149	7	3
	150	4, 19, 22, 24	71
	158	13, 17	27
	186	9	25
	194	25, 26	10
Florence	20	8, 13, 16	70
	21	6	13
	40	2, 8, 14, 30	232
	47	9, 12	98
	71	17, 23	140
	72	31, 33	48
	84	10, 17	129
	116	11, 15	51
	122	5, 7, 23, 26, 27, 29, 30	257
	149	3	69
	151	15	219
	159	12, 19	39
	165	65	30
Lakewood	32	13	62
	34	19	19
Laona	3	20	107
	8	9, 12, 13	60
	32	7, 12, 13, 14, 25, 26	38
	33	21, 25	33
	37	16, 19, 23, 24	34
	66	2, 20	92
	69	6, 7	117
	78	8, 16	132
	80	4	103
	82	1, 2	200
	110	1, 6, 20	76
	119	13, 21	78
	121	8, 12	101
	133	3	61

APPENDIX B (CONT.)

Nicolet National Forest White Spruce (cont.)

District	Compartment	Stand(s)	Acres
Laona (cont.)	147	2	27
	164	21, 23, 26, 30, 32	126
	166	2, 4, 7, 12	87
	167	2, 19	108
	168	11	19
	172	1	38
	173	2, 3, 16, 19, 23, 27	80
	174	24, 25	34
	251	2, 4, 6, 12, 16	51
Total white spruce			3,938

Hemlock

District	Compartment	Stand(s)	Acres
Eagle River	5	23	17
	12	1	20
	20	1	15
	24	8, 9, 13, 19, 22, 24 26, 27, 30, 35, 47	130
	61	39	20
	64	3, 6, 10, 12, 15, 17	124
	65	12, 17, 27	15
	86	31	5
	118	8	40
	119	7, 10	25
	177	22	54
	179	3	10
	193	12, 13, 17, 19, 26	87
	194	12, 16, 28	134
	222	4, 16	42
Florence	123	6	30
	150	13	9
	176	34, 40, 68	18
Laona	29	7, 11, 13	76
	33	21	7
	37	1, 7	41
	60	2, 5	32
	74	2, 12, 15, 19	189
	89	35	15
	259	6, 7, 8, 20, 12	49
Total hemlock			1,204

Total Nicolet National Forest 5,142

Chequamegon National Forest

White Spruce

District	Compartment	Stand(s)	Acres
Park Falls	12	9, 18, 21, 26	160
	53	2, 4, 14, 23	237
	59	10	17
	60	6, 8, 9	75
	61	14, 20, 21	217
		25, 27	
	143	17, 30	110
	144	30	13
Hayward	102	49, 51, 56	128
		57, 58	
	105	1, 31, 34, 37	124
	115	2	29
	117	17	14
	132	12	16
	135	43, 46	37
	145	2, 32, 36	420
	152	3, 5, 20, 31	79
	153	2, 9	128
Glidden	44	1	52
	107	16, 30	70
	82	1	30
	66	3	23
Medford	69	1, 12	91
	84	35, 38	51
	85	15, 25	121
Total white spruce			2,242

Balsam Fir

District	Compartment	Stand(s)	Acres
Medford	71	1, 25	146
Total balsam fir			146
Total Chequamegon National Forest			2,388